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MENTAL AND PHYSICAL CORRESPONDENCE IN TWINS. II

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III. THE BASIS OF CORRESPONDENCE AND DISPARITY IN TWINS

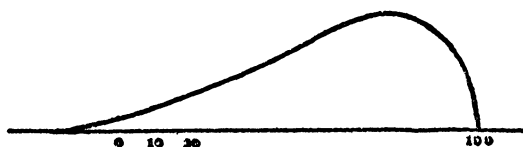
The problem of resemblance in twins is one of critical significance. If we could solve it with any completeness even for one pair of duplicate twins, we should thereby gain much insight into more general problems of heredity, development and education. Dr. Morton Prince has called double personality a veritable gold mine for the study of psychological phenomena. Duplicate twins represent double personality in a different but no less pregnant sense.

Individual differences among unrelated human beings are almost infinite in variety. We do not expect even two leaves from a forest to be exactly alike; much less human beings. Persons prominent in public life often have a double; but the degree of identity will usually not bear very close inspection. Very rarely indeed do police bureaus find cases of even apparent physical duplication among criminals and crooks. A remarkable and authentic case, reported from the U. S. Penitentiary at Leavenworth, Kansas, relates of two colored prisoners, Will West, No. 3426, and William West, No. 2626, whose photographs and Bertillon measurements as well as names were strikingly alike, and who with their hats on were almost indistinguishable. But even this resemblance proved to be superficial, and did not rest on any developmental identity.

The question of correspondence and disparity in twins involves, of course, the deeper problem of the genesis of twins. It can not be said that this problem has been solved. Biologists have for some time accepted a classification of human twins into two distinct types: (1) fraternal twins, who may or may not be of the same sex, who show ordinary sibling or fraternal resemblance, and are presumably derived from two separate eggs (dizygotic); (2) duplicate twins, who are always of the same sex, closely resemble one another, and supposedly originate from one fertilized egg only (monozygotic). The existence of both types of twinning has been indisputably established in the lower animals. There can be little

question about the occurrence of dizygotic (biovular) twinning in the human family. There has, however, been some question in regard to the frequency of mono-zygotic twinning; and the possibility of reconciling specialization of resemblance and disparities in co-twins with this mode of genesis. Biologists and embryologists, however, continue to recognize two distinct types of human twinning. Obstetricians have adopted the same distinction, and maintain that it is usually possible by an examination of the placenta and foetal membranes to determine whether any given pair of twins was mono- or bi-oval in origin.

Thorndike, as we have seen, seriously doubts whether twins represent two distinct modes of fertilization and genesis, and thinks there is no need of it, whatever, to explain the facts of the likeness of twins, "for the closest likeness grades off gradually into notable difference as one ranks twin pairs by their resemblance." (Figure



From Thorndike's Measurements of Twins.

Archives of Philosophy, Psy. and Sci. Methods, Vol. I, p. 44.

FIGURE 13. THE FORM OF DISTRIBUTION OF RESEMBLANCE IN TWINS

13) He admits that there is an increase in the resemblances of children born at the same time over ordinary siblings; but thinks it is due to a reduction of variability among germs produced at the same time. In his series of twins, he found that even the most similar twins differ markedly in some traits. This specialization of resemblance he holds disproves the existence of the identical-twin species. "The most identical twins will in *some* respect be less like each other than ordinary siblings." His argument is summed up as follows:

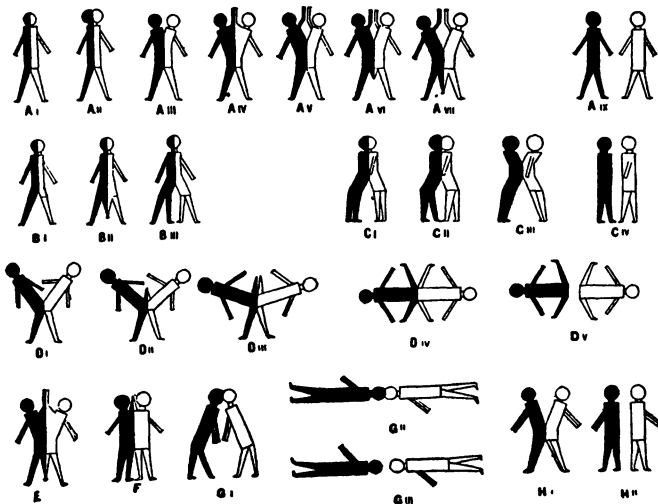
The objections to the genesis of any considerable percentage of twins by the development of two individuals from one ovum after fertilization are: first, this specialization (of resemblance) which is well nigh universal; second, the non-appearance of any such well-defined group of especially similar twins; third, the fact of triplets, all three as identical as any two twins; fourth, the too great frequency of close resemblance.

Let us consider some facts regarding the development of twins, which may perhaps diminish or divert the force of these objections.

Bateson has given us a very broad conception of twinning in his formula "the production of equivalent structures by division." He regards it as a fundamental manifestation of life. "When I look at a dividing cell, I feel as an astronomer might do if he

beheld the formation of a double star; that an original act of nature was taking place before me." Cellular division, as such, is not twinning; but the tendency of the divided or repeated parts to assume symmetrical relations may be so regarded; and this tendency is an almost universal feature of biological mechanics. The fact that the experimental embryologist can bring about the growth of a paired structure by a simple wound of a single limb bud reveals the fundamental nature of twinning. Of similar significance is the fact that Loeb produced a 90 per cent. increase in twins by a simple immersion of his experimental eggs in lime-free sea water, which caused the segments of the living eggs to fall apart as they were formed. Newman, likewise, regards the phenomenon of twinning as a "very fundamental process almost universal in the field of biology. For wherever we have bilateral doubling, we have twinning in some form."

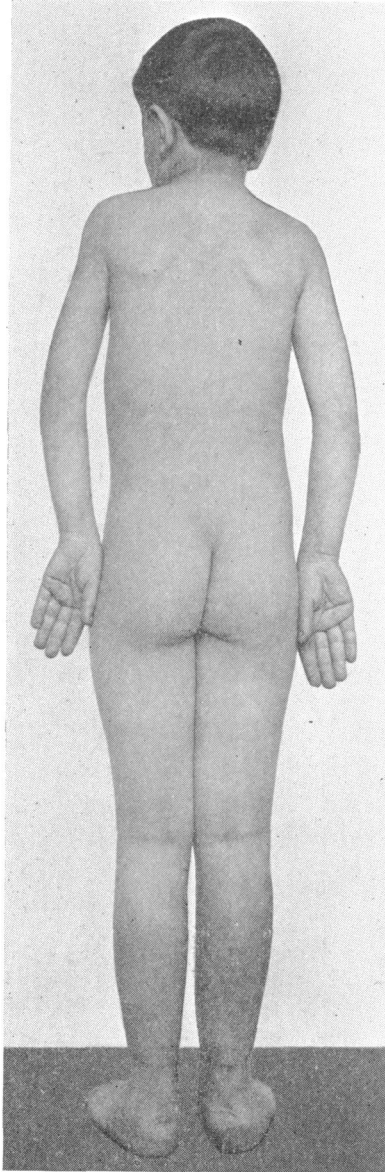
From this point of view every bilateral individual may be conceived as being morphologically a pair of twins. This view is so legitimate that it need not be called paradoxical. The human individual is undoubtedly derived from a single fertilized cell. He is monozygotic in origin. From this zygote, through a process of symmetrical division, develop all his right and left hand homologous organs and the right and left halves of his "unpaired" organs and structures. He is a product of developmental duplicity. Now in the case of true, complete monozygotic twins, this process of duplication has been carried to such a degree that two offsprings



From American Journal of Anatomy, Vol. III, p. 473.

FIGURE 14. WILDER'S DIAGRAMS SHOWING THE INTER-RELATIONS OF VARIOUS SORTS OF DIPLOPAGI AND DUPLICATE TWINS

result from the single ovum. A perfectly symmetrical bilateral individual on the one hand, and a perfect pair of duplicated individuals on the other represent the ideal extremes of the process of twinning. Between these extremes there are many gradations and deviations, some of them benign, other monstrous, in charac-



*From Gesell's Hemi-hypertrophy and Mental Defect,
Archives of Neurology and Psychiatry, Vol. VI, p. 409*

FIGURE 15. A CASE OF HEMI-HYPERTROPHY, AGE 13

ter. Instead of a full twinning of the whole body, there may be twinning of various parts or only of one part. For example in the type of twinship known as *diprosopus diopthalmus*, described by Ballantyne, "the size of the head and the presence of two noses may be almost the only signs of duplicity."

Wilder's diagram, reproduced in Figure 14, shows graphically some of the numerous interrelations of diplopagi and duplicate twins. We should, I think, add the condition of hemi-hypertrophy to this series. Hemi-hypertrophy would be represented by a drawing in every respect like the normal figure A1, except that one half would be portrayed as definitely larger than the other. Hemi-hypertrophy is a total unilateral enlargement of one half of the body. This rare anomaly may be interpreted as an atypical or imperfect form of twinning,—a variant of the same process which may produce a double headed monster, or a completely symmetrical individual. Sometimes the disparity of the two sides of a hemi-hypertrophic individual is so great that there will be eight teeth on the enlarged side when none have erupted on the other; as though the individual had two physiological ages, or as though he were two different, conjoined hemi-creatures! Careful measurements of a case of hemi-hypertrophy, studied by the author when the subject was 13 and 20 years of age, showed that the mild gigantism was a permanent condition and involved apparently the whole right side. (Figure 15.) The right half of the nose was larger, the right nares twice that of the left in diameter, the right palpebral fissure was wider; on the same side the cheek and lips were fuller; the arm was larger, the right hand was relatively more enlarged than some of the other structures; the right leg and foot were similarly enlarged. On palpation the hypertrophied side had a more doughy feel than the left. This suggested redundancy of the subcutaneous tissue, but the roentgen rays showed that the bones themselves had participated in the hypertrophy. (Gesell, *Op. cit.*)

Davenport regards size or stature as a unit character of inheritance, subject to mendelian principles; but this does not assist us in interpreting the curious stature anomaly embodied in hemi-hypertrophy. We are probably dealing with some quantitative imbalance in the processes which normally determine symmetry and twinning.

Newman has made suggestive researches into heredity and organic symmetry in armadillo quadruplets. He has noted some cases in which one lateral half of the body has quite a different number of scutes from the other half, and one of these halves resembles the maternal condition. Since each set of quadruplets

have the same genetic constitution in as much as they arise from one zygote, he concludes that some irregularity in the mechanism of the mitotic cell division is responsible for the anomalies of symmetry. This factor is by no means a simple one. "Now in the armadillo there are many evidences of a system of symmetry common to all of the quadruplets, upon which has been superimposed a secondary symmetry system between twins. This in twins is more or less obliterated by a tertiary symmetry between the antimeric halves of the single individuals."

R. G. Harrison discusses rules of symmetry in his monograph "On Relations of Symmetry in Transplanted Limbs." This study is based on 462 cases of grafting of limb buds in *amblystoma punctatum*. He agrees with Morgan that the potential factors of symmetry reside in the constitution of the egg. "It is the intimate protoplasmic structure that underlies symmetry." Likewise reversal of symmetry. "As an alternative to the hypothethis of rotation, we might consider reversal as due to reversal of molecular asymmetry according to analogy with the behavior of optically active compounds." "There is an analogy between the production of enantiomorphic limbs and the production of situs inversus viscerum, as effected by Speemann. (Speeman obtained a large number of twins in Triton by constricting the eggs in segmentation stages or in early blastula. In many of the cases one individual, usually the right, developed complete situs inversus viscerum.) Either the reversal may be due to reversal of the intimate structure, or it may take place in spite of the intimate structure through the direct action of mechanical factors on the individual parts of the differentiating system." (*Journal of Experimental Zoology*, Vol. 32, p. 1.)

Another form of asymmetry, no less startling than hemi-hypertrophy is that of gynandromorphism. A gynandromorph is an animal that is male on one side and female on the other. This differentiation may include the reproductive organs, gonads and ducts. Usually it is longitudinally bilateral, but it may be antero-posterior. This curious phenomenon is most frequent in insects but has been reported in birds and in a few mammals. A beautiful case was described in a mutillid wasp in which the male half of the body was black and winged like the male while the female half was a rich red and wingless.

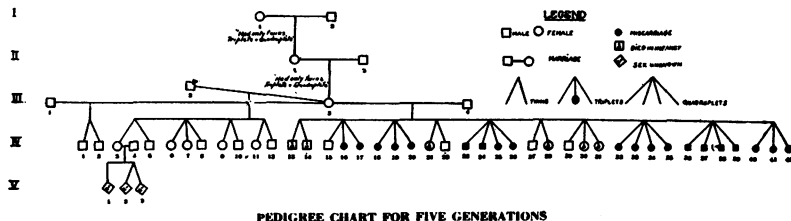
The problem of gynandromorphism has been extensively studied by T. H. Morgan and C. B. Bridges and reported in their contributions to the genetics of *Drosophila Melanogaster*. They found one gynandromorph among every 2,200 flies. The authors consider a gynandromorph to be a hybrid whose genes are carried by the sex

chromosome; and they give definite evidence that the peculiar sex mosaic condition is due to an elimination of one X chromosome, usually at some early division of the segmenting nuclei.

The asymmetry embodied in hemi-hypertrophy and even in gyandromorphism is benevolent when compared with the deformities and monstrosities that may occur in the field of pre-natal pathology, where one twin becomes a mere parasite upon its normal cotwin. The germinal conditions may have determined an entirely normal pair of twins, of equal partnership in the rights of life. But in all single ovum (monozygotic) twins there is always a certain area of the placenta in which there is an anastomosis between the two vascular systems of the pair of embryos. If the balance of power between the two uterine inhabitants is equal; and if no marked positional or physiological preference is given to either one, this partial community of blood supply carries no penalty. But a stronger or favored embryo may appropriate an increasing monopoly of blood, so that the sibling foetus degenerates into an acephalic, acardiac, trunkless or amorphous parasite. Here, as Bal-lantyne remarks, nature "attains to the extreme limit of teratological expression." One twin may be relatively normal, but the cotwin dwindles developmentally into a vegetative mass of malformed, or unformed tissues.

This glimpse into the teratology of the subject shows that twinning actually expresses itself in two apparently contradictory end results. It may produce perfect symmetry and mirror imagery; or it may produce gross disparity. Nowhere in the study of man do we find such complete duplication of individuality as among monozygotic twins; and nowhere do we find also such profound and monstrous degrees of individual difference as among twins of monozygotic origin. In this biological sense the range of individual difference is incomparably greater among monozygotic twins than among unselected pairs of individuals; for we must include among the former those aberrant fetuses which are so extraordinarily grotesque that they have lost all semblance even to the embryonic human form.

It must be recognized that dizygotic twins may undergo secondary fusions in the developmental period and be born as conjoined twins; but true double monsters are placed more readily in the monozygotic category. Wilder holds that there is a close relation between duplicate twins and double monsters; of the type in which one twin is a degenerate parasite upon the other, and also of the lightly conjoined type of twins, who can sometimes be severed successfully by a surgical operation. Newman agrees with Wilder in the view that these are all monozygotic in origin, and



PEDIGREE CHART FOR FIVE GENERATIONS

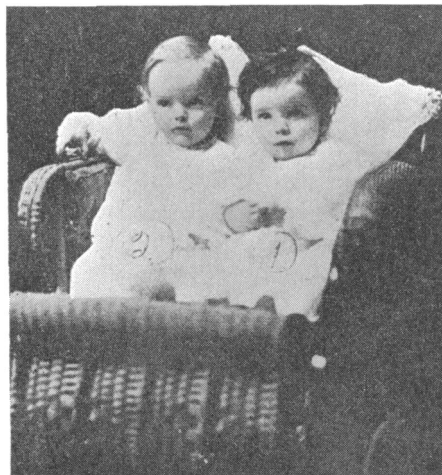
The diagram above illustrates a remarkable record of "a woman who, in three successive marriages, has never had a single child at a birth." A history of this case shows that there have been multiple births in each of four successive generations. The propositus who is indicated by No. 3 in the third generation (III-3) was married three times. (Fig. 16.)

From the Journal of Heredity, Vol. 10, p. 383.

FIGURE 16. A CASE OF HEREDITY TWINNING

asks the question, "What more natural, therefore, than to infer that separate twins which are of the same sex and strikingly alike are also monozygotic?" Parenthetically it may be stated that Newman has definitely established the fact that armadillo twins are monozygotic in origin, and that twinning is a specific hereditary character in this species.

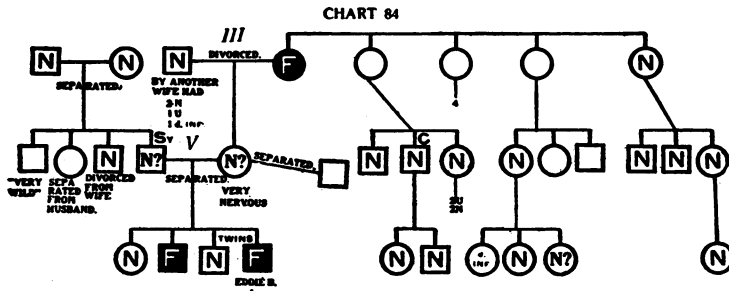
The problem of physical and mental resemblance in dizygotic twins is more simple. Dizygotic twins must be considered merely as two contemporaneous individuals. As a class such contemporaries doubtless show a higher degree of psycho-physical resemblance than non-contemporaneous siblings, but in any given pair we must be prepared to find ordinary fraternal individual differences. Such twins usually look no more alike than ordinary brothers and sisters, are easily distinguished by physical, mental and temperamental characteristics. (Figure 17.) Indeed one such



From Journal of Heredity, Vol. 10, p. 402.

FIGURE 17. FRATERNAL (DIZYGOTIC) TWINS

Their mother writes, "They are so utterly unlike in every way that it is hard for any one to realize that they are twins."



From Goddard's Feeble-mindedness, its Causes and Consequences

FIGURE 18. FAMILY CHART OF TWINS, ONE MENTALLY NORMAL, ONE FEEBLE MINDED

twin may be mentally normal while the cotwin is backward or even feeble-minded. Goddard made a study of the family histories of 327 feeble-minded individuals. Fifty-one of his charts recorded the birth of twins. In four of these cases, one of the twins was mentally normal and the other feeble-minded (Figure 18). Surprising as this may seem to those who make the term "twin" synonymous with resemblance, it is not difficult to explain. Two separate ova were in each case probably fertilized by separate spermatozoa. In one case both gametes were defective, in the other only one or neither. There is no reason to expect duplication or identity under such conditions of conception.

A few cases of twins have been reported in which one child was normal and the other of the mongolian type of mental deficiency (Figure 19). Mongolism is characterized by a small rounded



From Journal of Am. Medical Asso., Vol. 78, No. 1. (Dr. Stafford McLean).

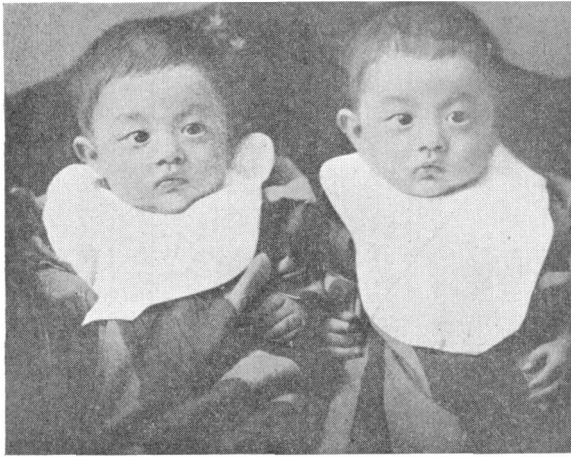
FIGURE 19. MONGOLIAN IDIOT AND NORMAL TWIN SISTER AT 6½ MONTHS

skull, hypertrophied tongue with enlarged circumvallate papillæ, oblique almond eyes, and frequently lax joints, broad, flabby hands and feet, defective circulation, and nearly always imbecile mentality. Mongolians look so much alike, it has been remarked, that they appear to be members of the same family. However, Mongolians themselves do not beget children and the cause of the condition is very obscure. If the cases of one Mongolian in a pair of twins have been correctly diagnosed and reported, it suggests that the twins were dizygotic and the defect one of specific hereditary transmission. If it represents an endocrine disturbance, it may be that the endocrine defect itself was germinally determined. It is, however, necessary to be cautious in conclusions on this point. I have, myself, seen a pair of mentally subnormal, duplicate twins, pupils in a special class, who presented physical and mental features intermediate between true mongolism and the simple clinical variety of feeble-mindedness. How shall we explain these semi-mongol or mongoloid types in presumably a genetically identical pair?

The necessity of caution in interpreting the rôle of chromosomes and hormones in asymmetric twins is well warranted by the confusion which associated itself with the rationalization of the freemartin. The freemartin is well known to cattle breeders as a sterile twin, born cotwin to a normal male. Professor Newman credits F. R. Lillie with having solved this baffling and controversial mystery. "Lillie's work has revealed the true nature of the freemartin; it is a sterile female whose gonads remain in the juvenile stage so that they resembles testes, and which has certain secondary sexual characters of the male due to the presence for a considerable period of male hormones in the blood borrowed from its male cotwin. The animal is hermaphrodite only in a very limited sense. The work leaves no question as to the dizygotic origin, not only of opposite-sexed, but also of same-sexed bovine twins."

If hormones play a regulative rôle in prenatal development, it might be argued that the interchange in blood supply made possible by the vascular anastomosis in the placenta of monozygotic twins, would tend to exert an equalizing influence upon the fetuses.

The term mongolian has just been used in a clinical and not an ethnological sense; but it indirectly recalls those instances in which twins actually present racial disparity rather than resemblance. This amazing possibility rests on the well recognized occurrence of super-fecundation, in which one impregnation is after a brief interval followed by another and the mother gives birth to dizygotic twins. Under illicit conditions there may be two fathers,



From Journal of Heredity, Vol. X, p. 428.

FIGURE 20. IDENTICAL TWINS FROM JAPAN, YEICHI AND YUJI OGATA, OF TOKIO

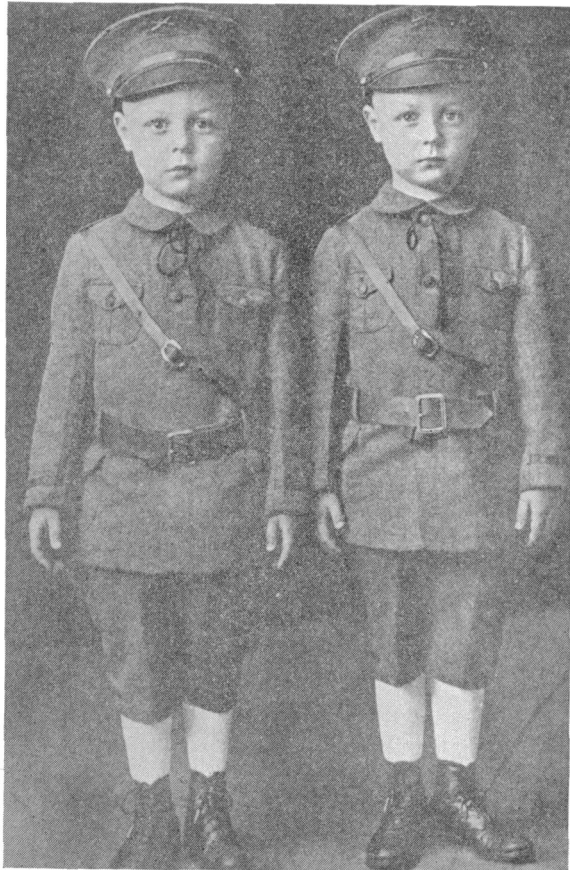
of not necessarily similar race, for the pair of twins. Dr. John Archer, the first man to receive a medical degree in this country, reported a case in which a white woman was delivered of twins, one white and the other mulatto.

We are, therefore, confronted with an extraordinarily wide gamut of quantitative and qualitative diversities in the field of human twinning. The factors which bring about these diversities are not only germinal, but post-germinal, genetic and developmental. Their combined action may help to obscure the bi-modality of the distribution curve for twin resemblances, but leave unimpaired the validity of a classification into the two traditional groups.

It must be remembered that there are wide variations possible within either of these groups. Neither process works with iron clad rigidity or uniformity. For example, Williams recognizes that single ovum twins may be produced in one or all of as many as four different ways: 1. By fertilization of two polar bodies. 2. By premature separation of one or more blastomeres from a segmenting ovum. 3. By cleavage of the embryonic area. 4. By double gastrulization of the blastodermic vesicle. Moreover we must recognize the indisputable occurrence occasionally of an ovum with double germinal vesicle (two nuclei). Boveri has suggested the additional possibility,—actually demonstrated on eggs of sea-urchins and bees—that a sperm may occasionally unite with only one half of a precociously divided ovum, leaving the other half to develop parthenogenetically (Danforth). Recently Professor R. S. Lillie has suggested that the process of development is

basically regulated by some physiological influence of a repressive or inhibitory kind comparable to chemical-distance action, which is indeed essentially a form of bio-electric control through potential-difference. We have already noted the existence of purely nutritional and hormone factors in the developmental period; and we have Newman's general observation that in human twins, "twinning is by no means a single fixed process, but is highly variable, evidently beginning earlier and being more complete in some cases than in others."

Now these various suggestion do not suddenly clarify the problem of correspondences in twins, but they do make more intelligible the distribution of correspondences and disparities which is actually found; and they do not necessitate the denial of a relatively frequent occurrence of monozygotic twinning.



From Journal of Heredity, Vol. X. p. 409.

FIGURE 21. TYPICAL DUPLICATES

Very pertinent to the whole question of resemblance of twins is Newman's theory of somatic segregation. The conception of specialization of resemblance is dependent, of course, upon some kind of unit character method of hereditary determination; but Newman holds that although every character has a genetic basis in the zygote, "the exact expression of character is dependent upon developmental or epigenetic factors that vary in each individual case."

For this reason there may be disparities between two sides of an individual, disparity even in the friction ridge patterns of his two hands; or a disparity in stature as we have noted in our case of hemi-hypertrophy. Such asymmetries are expressions of differentiation through somatic segregation.

"The unilateral appearance of an inherited unit character, such as a friction-skin pattern, almost certainly implies some unilaterality in the somatic distribution of the differentiating factor for this character. Whether the character appears in one or in both of a pair of twins (which are genetically equivalent to the right and left sides of a single individual), or, finally, whether it appears in one, two, three, or four of a set of armadillo quadruplets, depends on whether the differentiating factor is distributed during the earliest cleavage in a unilateral or bilateral fashion; in other words, whether, with respect to the differentiating factor in question, the earliest cleavages have been equational or differential."

In brief, the early somatic divisions in the genesis of twins may be fully as important agents in segregating unit characters, as are the germinal division which characterize the maturation of the gametes. Specialization of resemblance in twins is consistent with this view, but it is also quite consistent with a monozygotic interpretation of twins which reveal numerous fundamental correspondences.

The statistical facts concerning specialization of twin resemblance investigation will serve as a wholesome deterrent of rash generalization; but they should not prevent us from recognizing thoroughgoing similarity when it actually presents itself. After all, an accumulation of numerous specialized resemblances with a few exceptional disparities, in two paired individuals, amounts practically to duplication.

To a clinical psychologist who is so constantly impressed with the differences which obtain both among normal and abnormal individuals, it seems almost like a violation of the laws of nature to find in one afternoon two personalities which are practically indistinguishable. From the biological point of view, however, there is

no reason why such instances of almost complete duplicity should not occasionally occur. The germinal and the somatic determinations of development may be so nicely balanced during the period of conception and cleavage, that we may have two persons who, psychologically as well as morphologically, stand for but one individual to the pair. Of the case of A and B, described in the foregoing pages, Shakespeare might again have said, "The apple cleft in two is not more twin than these two creatures."

AUTHOR'S NOTE: The reader of this article may be acquainted with an interesting pair of twins. The author will be grateful to receive any letters or photographs, bearing on the problem of physical and mental resemblances in twins. He is particularly interested in developmental correspondences observed in infancy and childhood. Address: Yale University, New Haven, Conn.